**Advanced Interagency Consultation Training**

# Study Guide for Exposure Analysis

**Objectives of this Module**

1. Explain the intent of an exposure analysis and its links with other components of consultation.
2. Explain the process of developing an exposure analysis, and variations dependent on the scope of analysis.
3. Develop an exposure analysis.

*Glossary*

**Exposure:** The contact, or co-occurrence, of a stressor with a receptor (EPA 1998).
**stressor:** any physical, chemical, or biological entity that can induce an adverse response.
**receptor:** the ecological entity exposed to the stressor.

For the purposes of this course, we will refer to the "stressors" as the "effects" of the action on the environment, including listed species and designated critical habitat (the "receptors.")

**Exposure analysis:** the process of describing exposure in terms of concentration or intensity, duration, and frequency of exposure to a stressor that can affect an assessment endpoint.

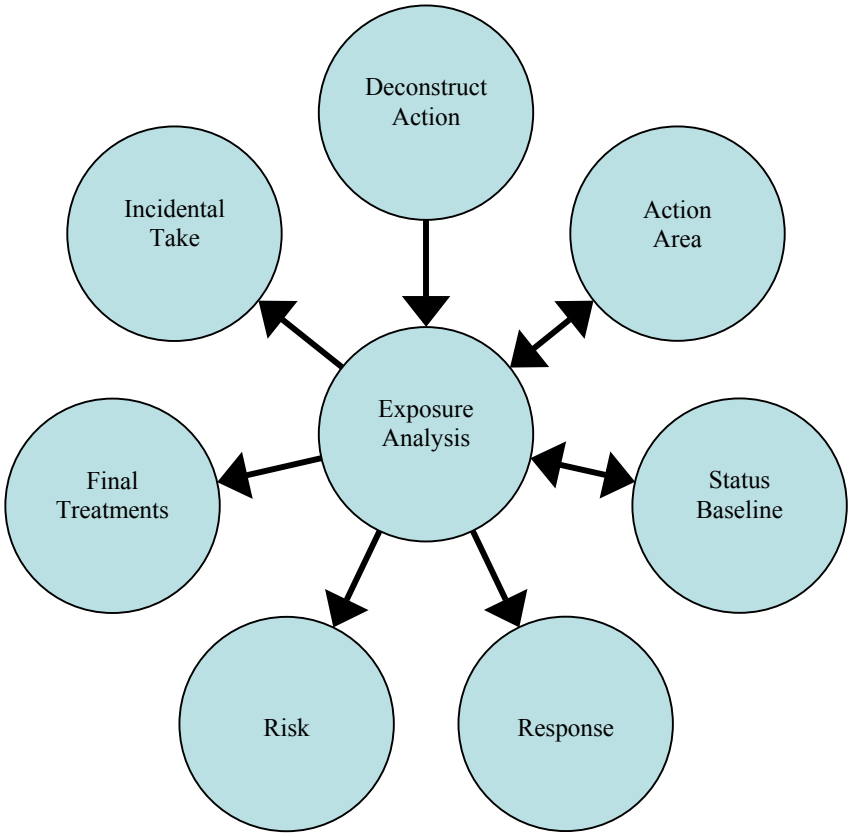
**Exposure profile:** the product of characterization of exposure in the analysis phase of ecological risk assessment. An exposure profile summarizes the magnitude and spatial and temporal patterns of exposure for the scenarios described in the conceptual model. Exposure profiles identify (a) how exposure occurs; (b) what is exposed; (c) how much exposure occurs; (d) when and where exposure occurs; (e) if exposure will vary depending on receptor attributes, stressor levels, or characteristics of the environment; (f) uncertainty associated with exposure estimates, particularly key assumptions and how they were handled, the magnitude of sampling or measurement error, the most sensitive variables influencing exposure, and uncertainties that can be reduced by collecting more information; and (g) the likelihood of exposure occurring.

## Introduction

The exposure analysis is meant to establish and describe the set of resources (species, populations, individuals, life stages or forms, or habitat elements) that are present in the action area and that may be affected by the proposed action or interrelated and interdependent activities. These resources "co-occur" with the effects (*e.g.,* degradants of pesticides, visual or auditory disturbance, loss of cover after herbicide application, etc.,) of the activities under consultation. This analysis provides the basis for discussions of conservation needs, possible and probable responses of exposed individuals, risk analysis, and potential treatments. Exposure is not equivalent to "adverse effect," but it is the determinant of "may affect." Individuals of a species or elements of CH may be exposed to the physical, chemical, and biotic effects of an action, but suffer no ill effects (equivalent to "may affect, not likely to adversely effect").

*Connections*

Exposure is the key, or link, between an action and the risk the action poses to the species, its critical habitat, and its ecosystem (resources). Your exposure analysis highlights the critical information to utilize from your diagnosis of the status of the species/critical habitat and the base condition or baseline of these listed resources or, conversely, highlights the critical information and analysis that should be included in these assessments. Exposure also defines the range of responses you would expect from individuals of the species or elements of critical habitat and the ultimate risk those responses pose to the likelihood of survival and recovery and conservation value of the resources.




A complete deconstruction of the action will provide the foundation of your exposure analysis. As the elements of the action are separated, the overlap between resources and the spatial and temporal impacts of the action components becomes apparent. This results in a geographical and temporal description of the exposure "area" for each component. By focusing on this description, we can then parse out who will be affected by what, which then tells us what infomation we should concern ourselves with in assessing response and ultimately risk.

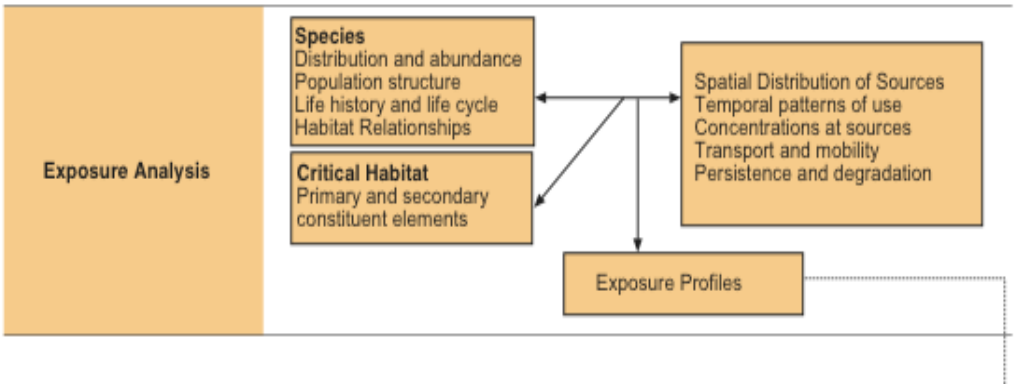
Once you have deconstructed the action and established your action area, the exposure analysis reveals:

- What are the specific effects causing exposure (physical, chemical, biotic)
- Where exposure may occur
- When exposure may occur
- How long exposure will occur

- How the exposure occurs (vector – direct or indirect)
- The frequency of exposure
- What the intensity of the exposure will be
- What resources (as listed or designated : DPS, ESU, Recovery Units) may be exposed to the effects
- Which populations of a listed species may be affected
- What life stages or forms of a species will be affected
- How many individuals may be affected
- What areas/constituent elements/functions of CH may be affected

This information is the "exposure profile." This profile is then used to establish the range of possible and probable responses to the action(s) and subsequently, the risk those actions pose to listed resources.

*Far right box refers to effects of chemical use*




Accurate reflection of the seasonality or phases of the action will add layers of complexity to this analysis. For example, the construction phase may impact juveniles during their molting season, whereas the operations of the project may affect all phases and stages, or only the adults during the breeding season. Periodic maintenance in subsequent years may also change the exposure profile. Cycles in population abundance or presence in response to predictable climactic shifts (flood/drought) will also modify the exposure profile. In addition, uncertainty as to the presence of the species in the action area, or even the life cycle of the affected species or processes affecting critical habitat elements, further increases the complexity in ways that can only be resolved via careful analysis of available evidence and development of compelling arguments based on this evidence or similar case studies.

These exposure profiles rely upon our understanding of the resources (as discussed in the Status and Baseline modules) to help us understand which individuals may be exposed and what the individuals may be doing while they are exposed (or what they expect from their environment – breeding sites of a certain quality and quantity, for example, which we then contrast with what they will get). This allows us to better focus both our discussions with the action agency and applicants and our written documents on those aspects of the species life history, dynamics, and risk factors that are relevant to the assessment at hand. For analyses of critical habitat, the process is much the same, but the focus shifts to assessment of those areas, elements, or functions of critical habitat exposed to the action.

The response analysis is based on the exposure profiles. Once we have determined which species, populations, and life stages or forms are likely to be exposed to the effects of the proposed action and interrelated and interdependent activities, we can identify the range of possible responses the exposed resources could exhibit. For example, examining lethal responses for a life stage that based on all available evidence is expected to essentially ignore

the stimulus would be unnecessary. The range of behaviors possibly affected is also limited to those exhibited by the exposed life stage.

Ultimately the risk analysis is informed by the exposure analysis. Through its effect on the response analysis, the exposure analysis provides sidebars on the possible range of responses. On its own, however, the exposure analysis describes: (a) which members (and how many) and populations of a listed species; and (b) which attributes of CH are likely to be exposed. This provides the framework for assessing the risk the expected responses will pose for the listed resources. In other words, our risk assessment is less likely to be based on reductions in reproductive behavior or reproductive rates if our exposed individuals are not the reproductive members of the population. By identifying the population members exposed to an action and their expected responses, we can better predict the likely effects to population dynamics, and therefore persistence.

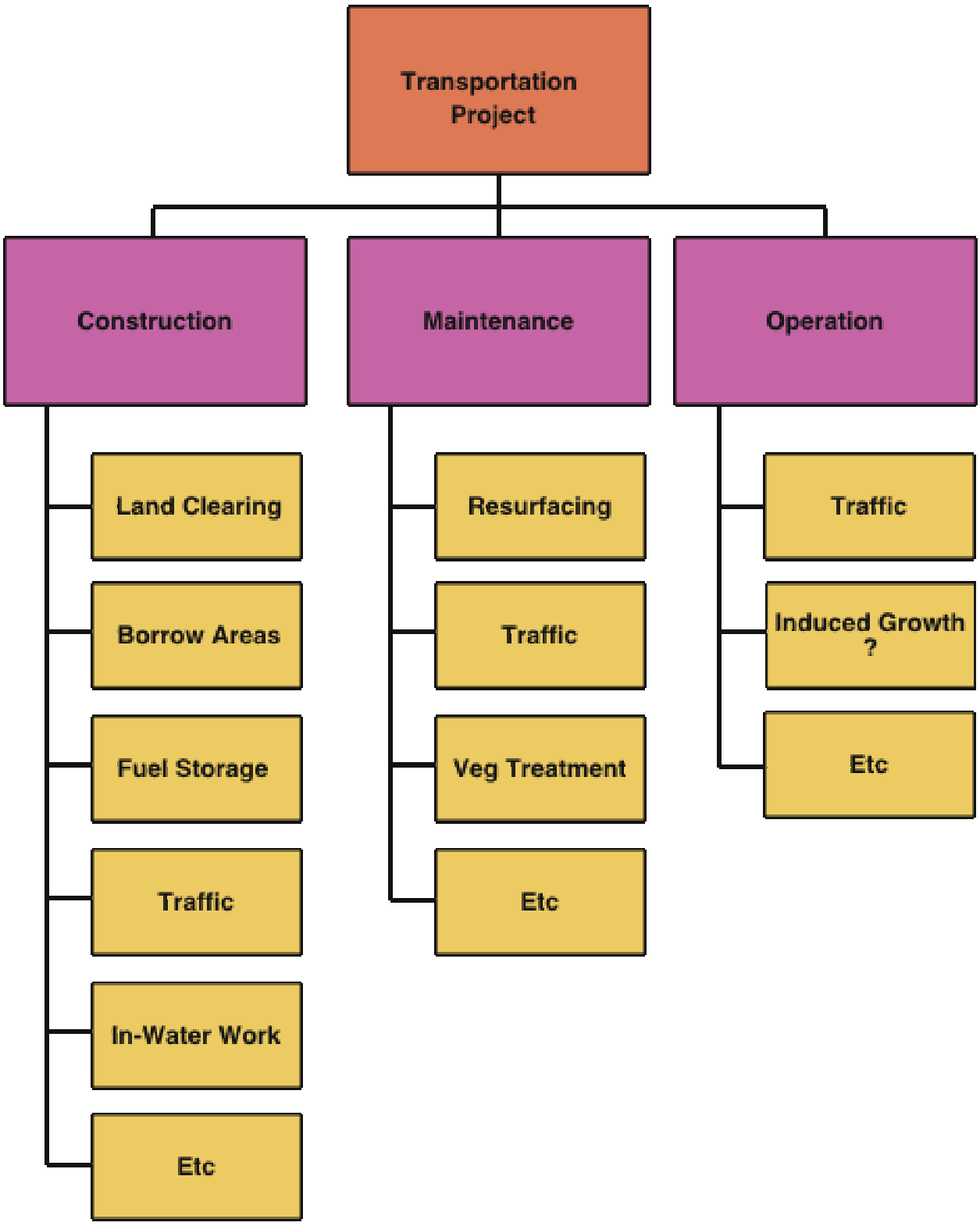
Exposure analyses can also expand the scope of our overall analysis. We should not feel limited to discussing only the exposed members of a listed species or elements of critical habitat, particularly for species with no designated critical habitat. Recognizing that the species exists within its local ecosystem and wholly depends on that ecosystem for its persistence, the exposure analysis should also address those facets of the ecosystem that we believe will be affected by the action. Of course, a simple statement that the whole ecosystem contained within the action area is exposed would generally cover this issue, but a more directed assessment of prey or forage species exposed to effects of the action, or indicator or surrogate species that we will use as the bellwethers of possible listed resources response would be more informative and easier to grapple with.

The exposure analysis sets the stage for any incidental take statement included with the biological opinion. As highlighted by the Arizona Cattlegrowers case, if we have not established that a listed species will be exposed to the effects of the action – and therefore is likely to exhibit certain responses that may qualify as “take,” then we have not established that incidental take is likely to occur (and therefore non-discretionary terms and conditions are required). In other words, once an individual of the species is exposed to the effects of the action, they will exhibit one of a possible range of responses. Therefore, exposure to effects is a necessary requirement for eliciting a response. If the individual is not exposed, they will not exhibit the response. As a result, exposure often dictates the type of treatments (conservation measures, reasonable and prudent alternatives, and reasonable and prudent measures) we may prescribe or negotiate for an action. For example, conservation measures incorporated into a project action often include measures such as construction windows meant to avoid or minimize the amount of exposure a listed resource has to a particular effect.

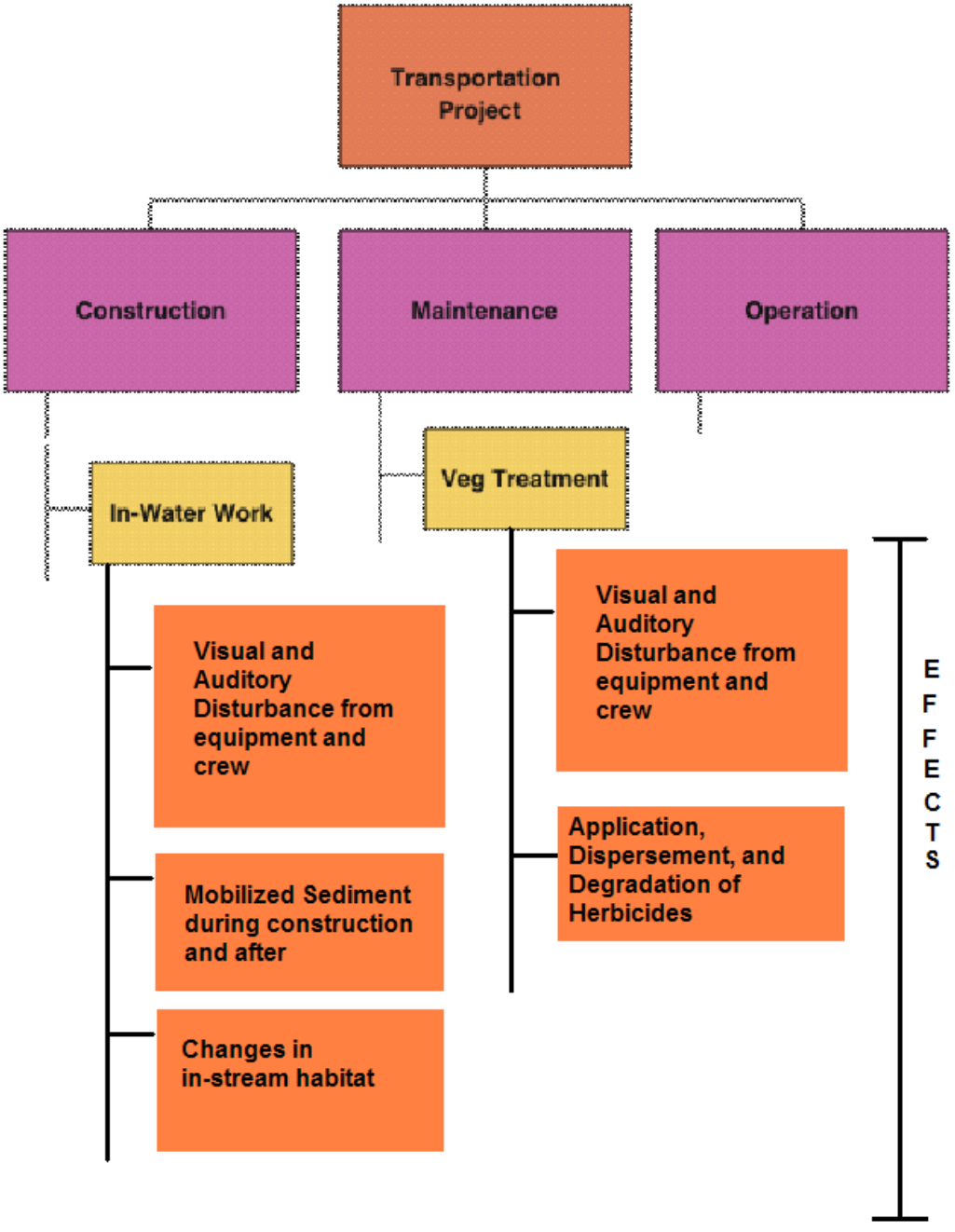
*Conducting an exposure analysis*

Once you have deconstructed the action and established your action area, describe the effects of each component of the action (for example, effects that are temporary vs. those that persist or permanently change the environment, effects that encompass the whole of the action area, and therefore more populations or individuals perhaps, than those effects that remain at the project footprint). These descriptions aid in determining both who will be exposed to the effects, and how the exposed resources will respond.

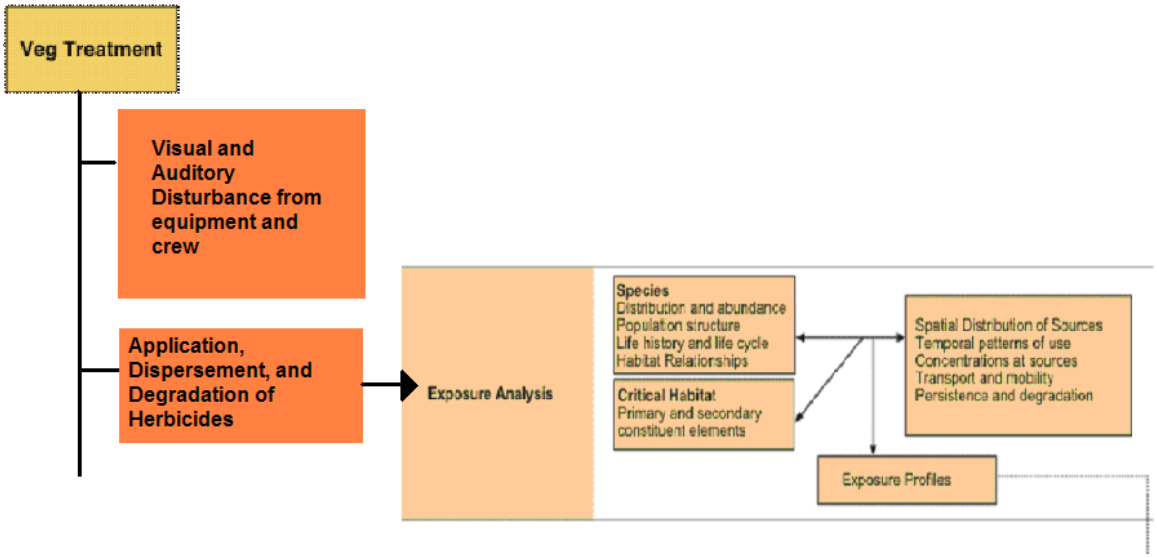
For example, in the figure below, the proposed action is divided into three phases: construction, operations, and maintenance. Each of these phases is further subdivided into separate components that comprise the overall phase. The effects associated with each of these components will each play into the exposure profile for the proposed action as a whole.


Transportation Project
Construction
Maintenance
Operation
Land Clearing
Borrow Areas
Fuel Storage
Traffic
In-Water Work
Etc
Resurfacing
Traffic
Veg Treatment
Etc
Traffic
Induced Growth ?
Etc

A brief assessment of two of these components, in-water work during construction and vegetation management during maintenance operations, indicates that some of the effects associated with these components include visual and auditory disturbances (from equipment and human operators), disturbance of aquatic substrates, mobilization of sediment during and following the action, and application of chemical compounds to vegetation and soil surfaces.



Looking back to the contents of our exposure profiles, we would use this information to develop the profile for these components. For example[1]:



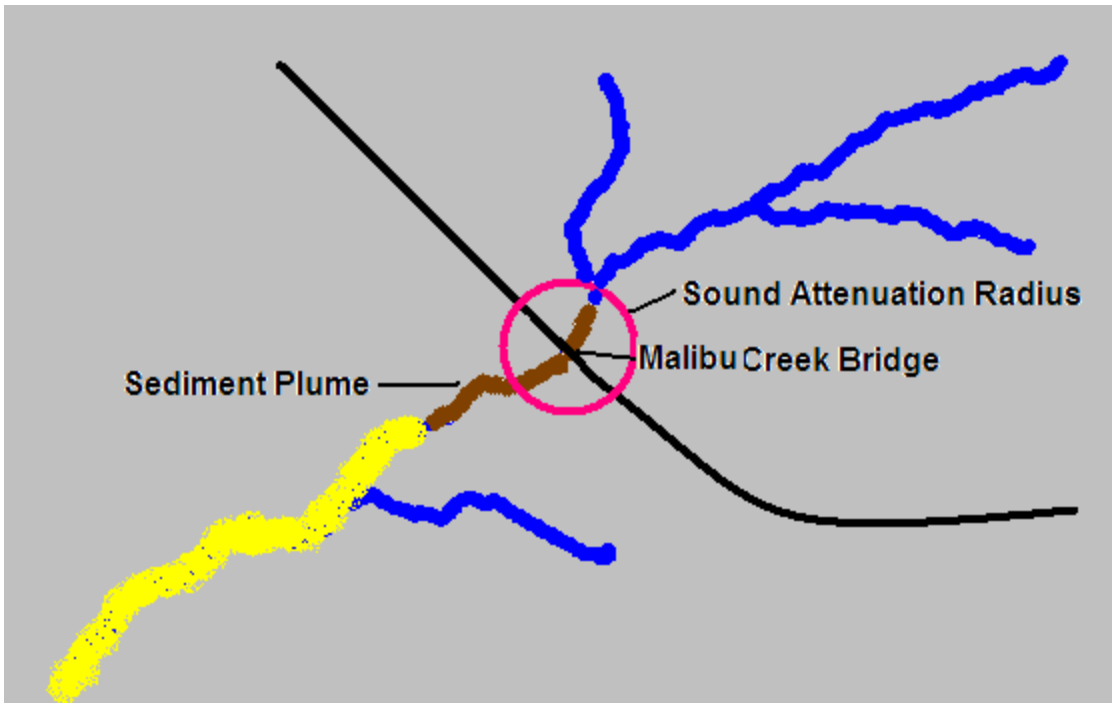

Starting with the construction phase, let's construct exposure profiles for the in-water work component.

**In-water work:**

- The effects: Visual and auditory disturbances (from equipment and human operators), disturbance of aquatic substrates, mobilization of sediment during and following the action.

- Where exposure to effects may occur: Malibu Creek, from the Malibu Creek Bridge downstream one mile and upstream 100 yards (the extent of detectable sediment mobilization, increased bed sedimentation, and changes to in-stream habitat). Plus the areal extent of sound attenuation from construction actions.

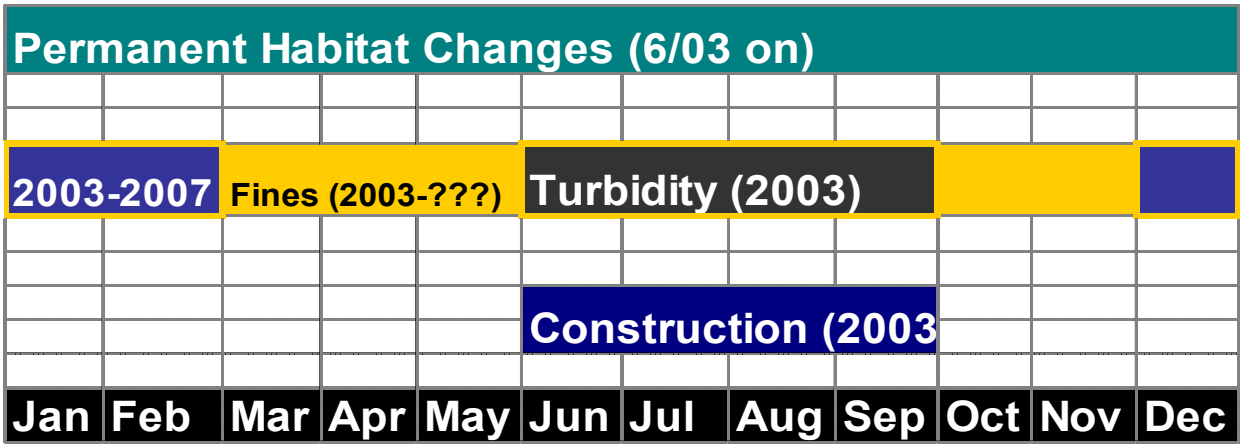
[1] Please note that the examples are summarized for discussion purposes and are by no means an exhaustive analysis of the components, resulting effects, and exposed resources.




- When exposure to effects may occur: Construction occurs June 1 through September 30, sediment mobilization expected to continue during winter flows above 500 cfs between 2003 and 2007. Stream morphology changes resulting from construction expected to occur subsequent to project completion and remain in perpetuity.

- How long exposure to effects will occur: Direct effects (construction effects, sediment mobilization and settlement) expected to occur intermittently until Spring 2007. Indirect effects (changes in habitat, settlement of sediment in spawning areas) expected to remain in perpetuity.

- The frequency of exposure to effects: Visual and auditory disturbances occur daily during construction period only. Instream aquatic habitat changes are permanent and continuous. Mobilization of sediments occurs during winter flows above 500 cfs between September 30, 2003 and Spring 2007.



- The intensity of exposure to effect: Workers and equipment on site during construction period. Sound volumes of 120 dB expected during in-water construction periods (lasting up to two hours per day). Sediment inputs expected to range from 5 to 50 cubic yards per season, declining volumes over time. Habitat change in the form of lost sinuosity, conversion of varied riffle-pool gravel substrate to combination concrete substrate and simplified channel form (loss of thalweg).

- How the exposure to effect occurs: Direct exposure during construction actions and during sediment mobilization events, indirect exposure resulting from in-stream habitat changes due to new structure within and across the stream and sediment mobilization events.

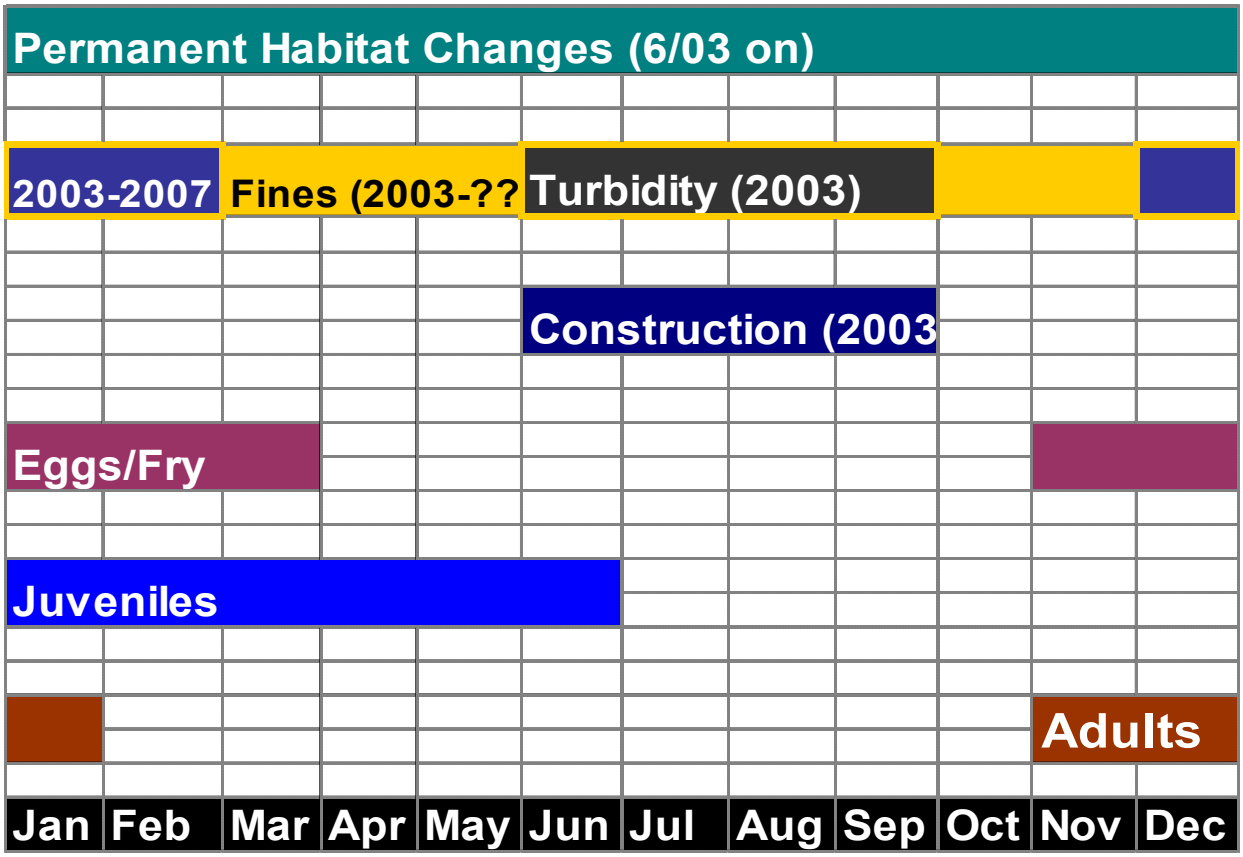
- What resources (as listed or designated : DPS, ESU, Recovery Units) may be exposed: Southern California steelhead (*Oncorhynchus mykiss*), an endangered species.

- Which populations of a listed species may be exposed: Malibu Creek population.

- What life stages or forms of a species will be exposed: Juvenile steelhead present during early portion of summer construction season. Adult and egg/alevin steelhead present during winter sediment mobilization period. All life stages of population exposed to permanent changes in in-stream habitat (see Figure below.)

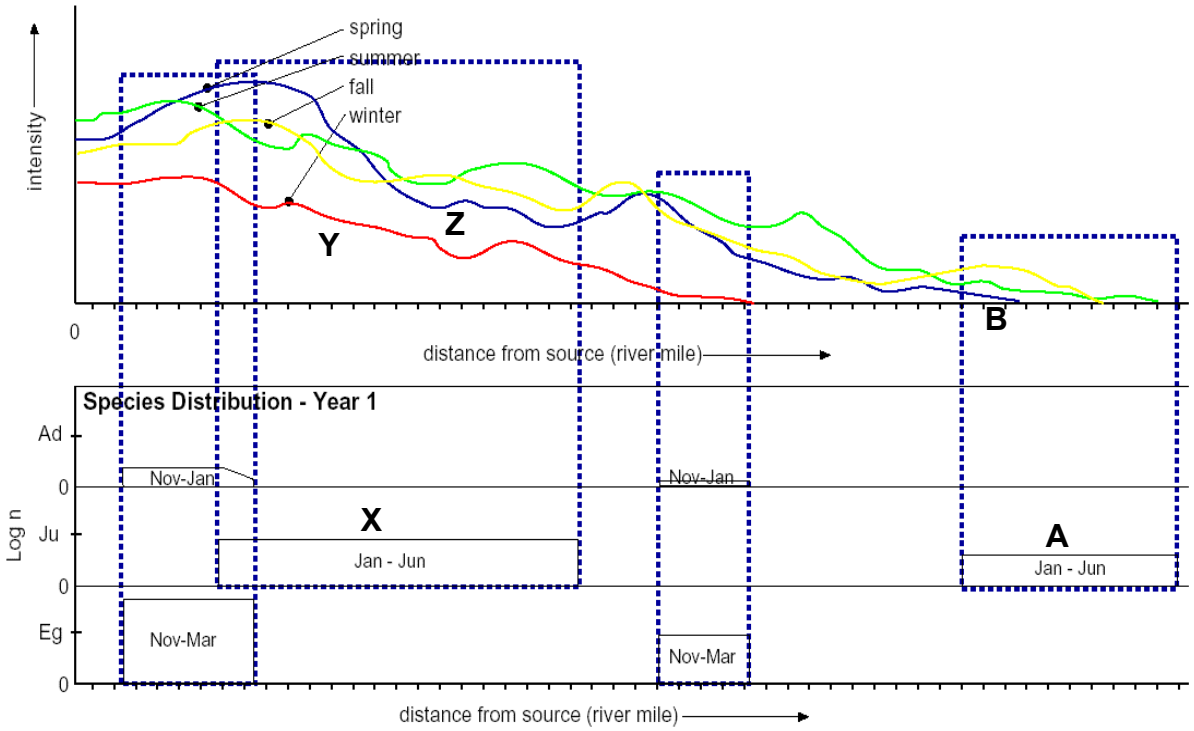
- How many individuals may be exposed: Available data indicates an adult population of 20 individuals, sex ratio unknown. Seine surveys indicate presence of 100 juvenile steelhead in the area.

- What areas/constituent elements/functions of CH may be exposed: Critical habitat not designated. The exposure area includes the upstream extent of spawning and rearing/holding habitat for steelhead.




As a result of this analysis, we have determined that all life stages of the Aliso Creek population of Southern California steelhead may be exposed to the effects of the in-water work component of the proposed action, but not all life stages are exposed to each effect. For example, we have determined that only juveniles of the population will be exposed to the visual and auditory disturbance or sediment mobilization during the construction period, but that all adult steelhead that spawn in the exposure area and their progeny (eggs and alevins) will be exposed to sediments mobilized in the area during subsequent winter flows over 500 cfs. Adult and juvenile steelhead will be exposed to the permanent changes in in-stream habitat that occur as a result of the new structure across and within the channel. And all life stages are expected to be exposed to the increased levels of fine sediments settled onto the streambed. In addition, due to the expected physical changes within the exposure area, spawning habitat (gravels, stream morphology) and rearing habitat (cover, eroding banks, gravels) are exposed as well.

Exposure profiles do not have to follow a strict format. They can take a variety of forms provided the form aid you in determining what listed resources will be exposed to the effects of an action. The assessment should be thorough enough to ensure you haven't missed aspects of the effects or resulting exposed resources. Here is a graphical example of an exposure analysis of sediment input from a construction site:




The dashed-line rectangles are the exposure profiles for the different life stages of the affected population found within the exposure area. The width of the markers within the adult, juvenile, and egg stages indicate the known or expected abundance of the number of individuals of that life stage in that area and at the times indicated within the markers. A summary of the exposure profile for the juvenile life stage rectangles would be: **X** number of juvenile steelhead are expected to be exposed to increased sediment levels of **Y** intensity during January through March and **Z** intensity during April through June in *the upstream portion* of the exposure area, and **A** number of juvenile steelhead are expected to be exposed to sediment levels of **B** intensity during April through June in *the lower portion* of the exposure area.

Repeating this exercise for the Vegetation Management component of the Maintenance phase will result in an additional exposure profile:

**Vegetation Management:**

- The effects: Visual and auditory disturbances (from equipment and human operators), application of chemicals to vegetation and soil surfaces.

- Where exposure to effects may occur: Highway 101 for 10 yards to either side of the Malibu Creek Bridge over Malibu Creek and extending 50 yards back from the streambanks (500 sq. yds of area at each bridge corner).

- When exposure to effects may occur: Vegetation management treatments are scheduled on 5-year intervals following project initiation (and initial treatment). Treatment is conducted between August 15 and October 15 of each treatment year.

- How long exposure to effects will occur: Project life cycle projected at 50 years.

- The frequency of exposure to effects: Visual and auditory disturbances occur during treatment period only. Habitat changes are temporary, with lost values typically replaced by the fourth year following treatment. Treatment occurs every five years.

- The intensity of exposure to effects: Workers and equipment on site during treatment period. Sound volumes of 80 dB expected during application. Habitat change in the form of complete loss vegetative cover within the treatment area, lasting until beginning of next growing season. Vegetative cover regrowth over next four years at rate of 25 percent replacement per year. Permanent change in diversity of vegetative species as native species are replaced by invasives or out competed by pervasive natives.

- How the exposure to effects occurs: Direct exposure during application of chemicals, indirect exposure resulting from changes in habitat types and bioaccumulation in local forage.

- What resources (as listed or designated : DPS, ESU, Recovery Units) may be exposed: **A.** Riparian vegetation along Malibu Creek for 10 yards up and downstream of the Malibu Creek Bridge and 50 yards back from each streambank (500 sq. yds at each bridge corner). Local vegetation consists of primarily willow and young cottonwood trees, non-native shrubs, and ruderal grasses. **B.** Southern Calfornia steelhead, an endangered species.

- Which populations of a listed species may be exposed: Malibu Creek population.

- What life stages or forms of a species will be exposed: **A.** All forms of riparian vegetation, from seeds, rhizomes, saplings, and up to mature plants. **B.** All life stages of steelhead exposed to indirect effects of habitat loss and change. No individuals present during application of herbicides.

- How many individuals may be exposed: **A.** All plants within the total 2,000 sq, yds of area treated. **B.** Unknown numbers of individual steelhead. Maximum adult population estimate for the creek is 20 adults. Past seine surveys have sampled up to 100 juveniles (range: 0-100 fish) within the 1,000 foot reach below the bridge during sampling events each June since 1995.

- What areas/constituent elements/functions of CH may be exposed: Critical habitat is not designated for this species. Other elements of the habitat the species depends upon are described in the above discussions.

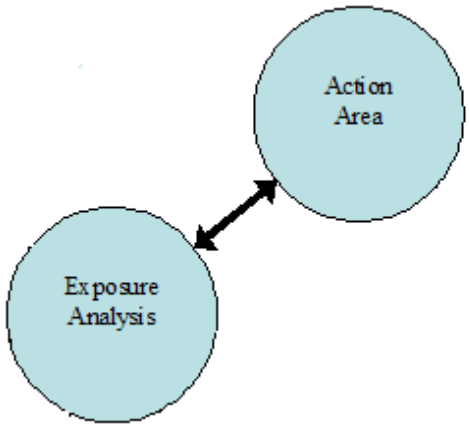
In the last example we develop an exposure profile that indicates that only habitat elements (riparian vegetation) will be directly affected by the proposed action. If we stopped our assessment at that point, we might determine that a listed species was not affected by the proposed action, since no critical habitat is designated for any listed species in this area. However, by following the effects (loss of vegetation, and eventual regeneration prior to re-treatment) we can see that the vegetation will be gone when our listed species is present. As a result, the listed species is exposed to the effects of the treatment program.

These profiles should be developed and maintained within the administrative record for the consultation. Summaries of the exposure profile would appear in the actual biological opinion or consultation letter. Note that at this point, no judgments have been made as to how the exposed

individuals will *respond* to these effects, merely that the listed resources will be present during the period of effects. This is our first step in determining the risk the action poses to the species (may affect; not likely to adversely affect; likely to adversely affect; likely to jeopardize; etc.,) and the first step in determining the likelihood of incidental take.

**Considerations**

Determining the resources that co-occur with a particular effect is not as simple as looking at the topo map overlay of the action area and listed/designated resource boundaries. Consider the action from all perspectives (birds-eye/topo view, cross-section, downstream, downslope, upstream, upslope, the species' limit of visual, aural, or chemical detection). Note that some of these variables may expand your action area (see figure below). Add the temporal fourth dimension to include seasonal migrations, boom and bust abundance cycles, re/establishing populations, seed banks, dormant species, etc.




Remember to assess the evidence we have available to support these determinations for those cases where there have been no surveys or surveys failed to detect presence (for whatever reasons, cryptic, no protocol developed, protocols too destructive) recently/historically/etc. Based on the available evidence, construct your reasoned argument supporting the presence and therefore exposure of the species to the effects of the proposed action and interrelated and interdependent activities. Don't forget to ensure that the administrative record supporting your consultation and resulting opinion or letter contains a clear discussion of this analysis!

Determine the life stages or forms exposed based on the spatial and temporal impacts of the action, the expected changes to the environment that individuals might respond to (changes in instream cover that juveniles not present during instream work would be exposed to) and, if available, past information on the individuals or habitat elements exposed to an action (fisheries observer data, water intake monitoring).

**Programmatic Exposure**

Exposure analyses change depending on the nature of the action, particularly for consultations on programs or other actions where future activities are unknown. This analysis will tend to be more general in nature and limited to species-as-listed or population level depending on the size of the action area (entire continental US v. Humboldt County in northern California v. the world's oceans). We often cannot narrow the exposure analysis down to individuals or life stages exposed because the nature, timing, or location of future actions is uncertain. As a result, further analysis to establish species "actual" presence in an area and therefore its exposure to the action's effects is deferred until future project-specific information becomes available. Once this

project-specific exposure is established, analysis of the likely responses of the exposed individuals and the ultimate risk to the species from the action can be completed.